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Producing Hybrid Seed: A Genetic Approach

Joseph A. Verica and Teh-hui Kao, The Pennsylvania State University

The majority of crops produced in the United States today are grown from hybrid seed, resulting in higher yields and a more uniform harvest. The commercial production of hybrid seed, a multibillion dollar business worldwide, involves crossing two inbred lines—with the anthers (male floral structures) removed from the seed-producing line to prevent self-fertilization. Anther removal, often performed by hand, is usually a labor-intensive and expensive process. There is a pressing need for more efficient and economical methods of hybrid seed production.

Toward that end, scientists at The Pennsylvania State University are conducting research, partially supported by the National Research Initiative (NRI) Competitive Grants Program, on self-incompatibility—a natural mechanism that prevents self-fertilization. A plant possessing the self-incompatibility trait can differentiate between self (genetically related) pollen and nonself (genetically unrelated) pollen, resulting in fertilization only by nonself pollen.

HOWARD P. NUERNBERGER

PETUNIA INFLATA, A MEMBER OF THE SOLANACEAE FAMILY, IS A SELF-INCOMPATIBLE WILD RELATIVE OF THE GARDEN PETUNIA.

The use of self-incompatibility for producing hybrid seed has been hampered to date by the difficulty of restoring self-incompatibility to inbred lines created during the development of most cultivated crops. Attempts to restore the trait by breeding cultivated crops with self-incompatible wild relatives have had limited success.

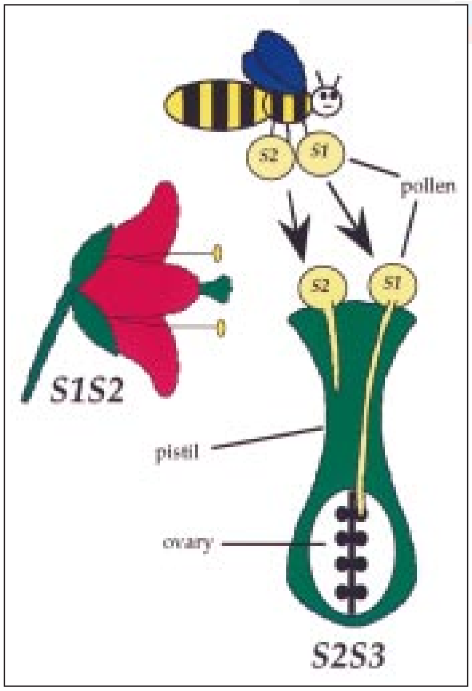
Taking a different approach, the Penn State researchers aim to identify the genes involved in self-incompatibility interactions, learn how the genes operate, and use genetic engineering techniques to restore self-incompatibility to cultivated species, thereby facilitating hybrid seed production. The scientists have chosen *Petunia inflata* (see illustration), a member of the Solanaceae (nightshade) family and a wild relative of the garden petunia, as a model system to study this trait.

The researchers seek to understand how the pistil differentiates between self pollen and nonself pollen.

Previous genetic studies have suggested that self-incompatibility in solanaceous species is controlled by a single genetic locus, called the *S* locus. A large number of alleles (variants of a gene) have been found at the *S* locus in natural populations. Although each petunia plant carries two such alleles, each pollen grain produced by the plant carries only one.

The diagram below illustrates the mechanism by which self-fertilization is prevented. The flower on the left, carrying alleles *S1* and *S2*, produces pollen grains, which carry either *S1* or *S2*. The pollen is transported by the bee to another flower, the reproductive area of which is shown in the lower part of the diagram.

If a pollen grain carries an allele matching one of those of the pistil (female floral structure) on which it is deposited, the growing pollen tube will not elongate sufficiently to reach the ovule and effect fertilization. As illustrated, two pollen grains have been placed on a flower that carries alleles *S2* and *S3*. Only the pollen grain carrying allele *S1* has fertilized an ovule.



JOSEPH A. VERICA

GENETIC MECHANISM BY WHICH SELF-FERTILIZATION IS PREVENTED IN THE SOLANACEAE. ONLY THE POLLEN GRAIN CARRYING ALLELE *S1* CAN FERTILIZE AN OVULE.

The research team seeks to understand how the pistil differentiates between self pollen and nonself pollen and how the growth of self-pollen tubes is arrested. To illuminate these areas, the team has identified one of the *S*-locus genes that control self-incompatibility interactions and has clarified the function of its gene products. For example, the researchers have demonstrated that proteins produced by the pistil act as ribonucleases, breaking down RNA and arresting the growth of self-pollen tubes.

The next step is to discover the gene at the *S* locus that controls pollen behavior in self-incompatibility interactions. Several lines of evidence suggest that the pollen *S* gene differs from the pistil *S* gene and that the interaction of pollen and pistil gene products elicits allele-specific inhibition of pollen tube growth.

Further understanding of all *S*-locus genes will increase the chances of restoring a fully functional self-incompatibility system to self-compatible crop species. This could have a tremendous positive impact on the efficiency and effectiveness of hybrid seed production. ❖

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